Effect of \textit{trans}-Cinnamaldehyde and High Pressure Treatment on Physico-chemical and Microbial Properties of Milk during Storage Periods

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Abstract

This study was carried out to investigate the effect of \textit{trans}-cinnamaldehyde and high pressure treatment on milk. Cinnamon oil milk was manufactured by high speed homogenization (3,000 rpm) and high pressure homogenization (500 and 2,000 bar) processing UHT milk and \textit{trans}-cinnamaldehyde of various concentrations (0 to 0.1\% (w/v)). Cinnamon oil milk was inoculated with \textit{Escherichia coli} (6.4 Log CFU/mL) and kept at 7\(^\circ\)C for 10 d to observe the antibacterial effect. The cinnamon oil milk containing 0.05\% (w/v) \textit{trans}-cinnamaldehyde initially began to show an antibacterial effect and \textit{Escherichia coli} completely died in cinnamon oil milk added 0.1\% (w/v) \textit{trans}-cinnamaldehyde on the 6th day of storage. The result of the TBA value showed that the addition of 0.1\% (w/v) \textit{trans}-cinnamaldehyde was also effective to protect lipid oxidation. In the physical properties of cinnamon oil milk, particle sizes were enlarged in all samples during storage periods and the total color difference of cinnamon oil milk was slightly increased as level of high pressure. The surface tension of cinnamon oil milk treated 2,000 bar was remarkably higher than other samples. It seems that \textit{trans}-cinnamaldehyde showed antibacterial activity and antioxidation effect at 0.05 and 0.1\% (w/v) of concentration. Remarkably, high pressure treatment did not influence its microbial property but slightly affected the physical properties of cinnamon oil milk.

Key words: \textit{trans}-cinnamaldehyde, high pressure homogenization, antibacterial activity, \textit{Escherichia coli}, milk

Introduction

Food safety and hygiene are important issues in the food industry and food borne diseases have been major problems in both developed and developing countries. Therefore, drugs such as antibiotics have been used frequently, and over prescription of antibiotics has causes a continuous increase in the tolerances of the strains to which they are applied, causing an even greater potential threat to human health.

The over-prescription of antibiotics leads to a reduction of their effectiveness. Hence, it is necessary to find new antimicrobial agents for food hygiene. Essential oils from plants are attractive substances to consumers, because they are natural food stuffs. It has been reported that their antibacterial properties can help extend the shelf-life of food. Moreover, essential oils are important raw materials in the food, perfume, and the pharmaceutical industries. Molecular encapsulation of essential oils improves their chemical properties and thermal stability. However, essential oils are very sensitive to the affect of light, temperature, oxygen, and humidity (Amrita \textit{et al.}, 2009; Burt 2004; Cevallos \textit{et al.}, 2010; Hossain \textit{et al.}, 2011; Rahman \textit{et al.}, 2011; Yossa \textit{et al.}, 2010).

\textit{Trans}-cinnamaldehyde (CIN, 3-phenyl-2-propanal) is organic compound that gives cinnamon flavor and odor, and accounts for the greater part (around 90\%) of cinnamon oil. It is pale yellow in color and forms a low viscous liquid. It has been widely known that the most common application of CIN is as a flavoring agent of foods such as gum, ice cream, candy, and beverages. CIN is increasing in importance as the most effective antibacterial and antioxidant essential oil, and has been used in beverages such as fruit juice, milk and so on. Some researchers have evaluated the antibacterial or antioxidant properties of spice extract, i.e. eugenol, gingerol, thyme, capsaicin, CIN and so on, and among them, CIN was ranked quite highly (Amrita \textit{et al.}, 2009; Hossain \textit{et al.}, 2008; Hossain \textit{et al.}, 2011). Many researchers have studied the antimicrobial effect of CIN. A research team at the University of Illinois found that CIN inhibits oral bacteria growth by $>50\%$; therefore, it could reduce production of volatile compounds that cause bad smells. It is particularly effec-
tive against bacteria living at the back of tongue, and reduces anaerobic bacteria populations by about 43%. The combination of cinnamon and clove essential oil shows a synergistic antimicrobial effect, although the active concentration of the essential oil must be determined (Cevallos et al., 2010; Chun 2012; Goñi et al., 2009). CIN could be used to extend the stability of foods during storage.

Food producers continuously search for ways to improve color, taste, texture and nutritional value. Over the years, homogenization technology has evolved because consumers have demanded products with a longer shelf-life and better stability. From the early 1980s new technology was introduced for fine emulsion, and is based on high pressure capacity (Cook and Lagace, 1985; Paquin, 1999). In recent years, high pressure homogenization (HPH) considered advanced production techniques of the food industries because it causes unique changes in the physico-chemical and functional properties of food materials, such as increasing encapsulation efficiency, bioavailability and physical stability, without causing excessive turbidity. Moreover, dairy products result in much finer lipid droplets through the application of HPH (Ciron et al., 2010; McClements and Qian, 2011; Van Hekken et al., 2007). Milk or milk-based products are typically heat treated to remove microorganisms and to prolong shelf-life. However, thermal processing could deteriorate some of the nutritional properties, and off-flavor and easily occurred protein denaturation (Bouaouina et al., 2006; Vassila et al., 2002). The stability of milk could be improved, and activation of bacteria inhibited without thermal processing, which causes changes in the nutritional and sensory properties (Smiddy et al., 2007; Wormbs et al., 2004).

In this study, cinnamon oil milk (CM) was manufactured by using high speed homogenizer and high pressure homogenizer with various concentrations of CIN and UHT milk. CM samples were inoculated with Escherichia coli ATCC 10536 which has been typical index of food quality in food industry in order to observe the antibacterial activity of CIN. CM samples were analyzed through microorganism observation, TBA value, particle size, pH, total color difference, and surface tension, for a storage period of 10 d at 7°C.

Materials and Methods

Materials

Trans-cinnamaldehyde (CIN: 98%) was obtained from Alfa Aesar (A Johnson Mathey Company, USA). Ultra High Temperature milk was purchased from the market milk (Seoul Dairy Co-op., Korea). Tryptic soya broth (TSB), tryptic soya agar (TSA), and MacConkey agar (MAC) were provided from Difco (Becton Dickinson and Company Sparks, MD, USA). Trichloroacetic acid was bought from DAEJUNG (DAE JUNG CHEMICAL & METALS, Korea) and thiobarbituric acid was provided from VWR International (VWR International Ltd., England).

Cinnamon oil-milk (CM) manufacture

CM (0% CM, 0.01% CM, 0.05% CM, and 0.1% CM) was prepared in various formulations. 0, 0.01, 0.05, and 0.1% (w/v) CIN was added into the UHT milk. UHT milk added CIN was performed by homogenization using a high speed homogenizer (Ultra Turrax® T25, IKA Labotechnik, Germany) at 11,000 rpm for 3 min. The CM emulsions were high pressure homogenized (HPH) under 0, 500 and 2,000 bar for 1 cycle by using the microfluidizer (Picomax® High Pressure Processor, MN400, Microinox, Korea). In every step of this process, the temperature of chamber was kept below 50°C through the use of an ice bath. The experiment was carried out to investigate the storage stability at 0, 1, 3, 6, and 10 storage d. During storage periods, CM was kept at 7°C.

Bacterial culture preparation

Gram-negative bacteria E. coli ATCC 10536 supplied by America Type Culture Collection (Manassas, USA) was used in this study to evaluate the activity of CIN in vitro. The E. coli was cultured on tryptic soya agar (TSA) at 37°C for 24 h for active microorganisms, and stored at -80°C in 50% sterile glycerol. Active cultures for experiments were prepared by transferring one loop full of cells from stock cultures to flask of tryptic soya broth (TSB), which were incubated at 37°C for 16-18 h.

Bacteria growth analysis

For the inoculation of CM with bacteria, E. coli were inoculated into 5 mL of TSB and grown for 18 h at 37°C in incubator to inoculate CM with approximately 1×10⁶ CFU/mL of it. Amount of E. coli of the CM were analyzed between 10³-10⁵ CFU/mL and the average log₁₀ counts obtained on MAC. The stock 1 mL of E. coli culture was diluted in the 0.85% NaCl solution 9 mL. 0.1 mL of bacteria solution was then spread on the surface of MAC plates. The plates were incubated at 37°C for 24 to 48 h. Detection of E. coli was based on enumeration of typical colonies according to the determination of colo-